Formation of Crenulated Clinoforms on Continental Shelves

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LONG-TERM GOAL

The long-term goal of this research effort is to improve understanding of sediment transport in a region of crenulated clinoform development on a shelf adjacent to a mountainous coast drained by rivers with episodes of high discharge.

OBJECTIVES

Our principal objective is to establish relationships between active sediment dynamics, cross-shelf transport and accumulation of sediment, and preservation of the stratigraphic record in the crenulated clinoforms that characterize large portions of the late Holocene prograding mud wedge in the Apennine shelf. Several specific objectives are being pursued: (1) identify the principal transport mechanisms acting in the topset and foreset region of a crenulated clinoform, (2) determine if, at present, seabed crenulations can be created and/or maintained by a specific sediment transport process, (3) provide information on the relative importance of gravity-driven flows versus current-driven sediment transport in the formation of clinoforms along the Apennine shelf, and (4) evaluate the role of internal waves in transporting sediment and inducing the formation of crenulated clinoforms.

APPROACH

The proposed approach consisted in measuring sediment transport process across a crenulated clinoform by means of deployments of a boundary-layer tripod in 20 m water depth and a mooring in 50 m water depth, off the Pescara River mouth. Another tripod provided by Dr. Andrea Ogston (U. of Washington) was deployed in the topset region of the crenulated clinoform in 12-m water depth. The boundary-layer tripod was equipped with a pressure sensor, three electromagnetic current meters and three optical backscatter sensors. Additionally, an Aanderaa RCM-9 current meter, equipped with turbidity, pressure, temperature and conductivity sensors was placed at the tripod frame. The mooring line was equipped with two RCM-9 current meters placed at 1 meter above the seabed and at 20-m water depth, in intermediate waters. Thermistors provided by Dr. Dave Cacchione (Coastal & Marine Environments) were mounted on the mooring line at numerous heights above the seabed to assess the presence of internal waves. Observations took place from late October 02 to early May 03 in two consecutive three-month deployments, following the EuroSTRATAFORM timeline plan for the Apennine field study. Instruments were retrieved and re-deployed in early February 03.

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WORK COMPLETED

During FY03 the entire field data set was collected by moored instruments described in the approach section. This included two three-month deployments of a boundary-layer tripod and only one three-month deployment of the mooring. Unfortunately the mooring at 50-m water depth was dragged probably by a fishing boat, and lost. During instrument deployment, turnaround and recovery, water-column was also conducted following a cross-shelf transect to characterize the hydrographic and nepheloid structure of the studied area. Among all the cruises conducted during FY03, ICM provided the research vessel *Garcia del Cid* for the instrument deployment cruise (October 02). Regarding meeting attendance, in April 03 we presented some preliminary results from the first deployment at the EGS-AGU-EUG Joint Assembly in Nice, France.

RESULTS

Sediment transport processes have been studied at the topset and foreset region of a crenulated clinoform and the role of wave-current interaction and internal waves on sediment resuspension has been investigated.

Several sediment-resuspension events were recorded at the tripod site, mainly related to Bora and Sirocco storms, during which current and wave shear stresses reached similar values. Sediment transport around the clinoform roll-over point (tripod site) was predominantly towards the SE, following direction of the coastal current and the bathymetry, but showing a significant offshore component that was intensified during storm events. Currents at the mooring site were also directed to the SE. In mid-waters they were clearly aligned with the local bathymetry, whereas near the bottom they had an important and continuous offshore component. This predominant offshore current behavior near the bottom seems to be associated with an intense bottom Ekman transport, which will enhance the suspended sediment transport from the topset down the foreset region and contribute to the development of the clinoform feature. In addition, activity of near-inertial waves was also recorded by the moored current meters and temperature sensors. The spectral analysis of the mid-waters time series indicates an absence of the near-inertial peak (17 h) in both current components and in the turbidity, but a noticeable signal in the temperature. Near the bottom, the temperature record, and particularly the cross-shelf velocity component and turbidity records, show a clear near-inertial signal, whereas the along-shelf velocity spectra lacks of it.

During periods characterized by a strong near-inertial fluctuations, increases of the water turbidity clearly coincided with the offshore direction of the cross-shelf velocity component and with strong temperature fluctuations through the water column (Fig. 1). During these events, velocities in the cross-shelf and along-shelf components were similar, which suggest that near-inertial internal waves also contribute to the offshore transport of suspended sediment across the crenulated clinoforms. Cross-shelf CTD sections indicate the presence of a surface nepheloid layer, being constrained by coastal colder and less saline waters, and the development of a bottom nepheloid layer that detaches where the thermocline intersects with the seabed, which can be created by interaction of internal waves with the seafloor. Further analysis about the role of near-inertial internal waves in the sediment dynamics of the study area will provide insights for understanding if this mechanism could have created and/or maintained the crenulated clinoforms that that extends along the Apennine shelf.

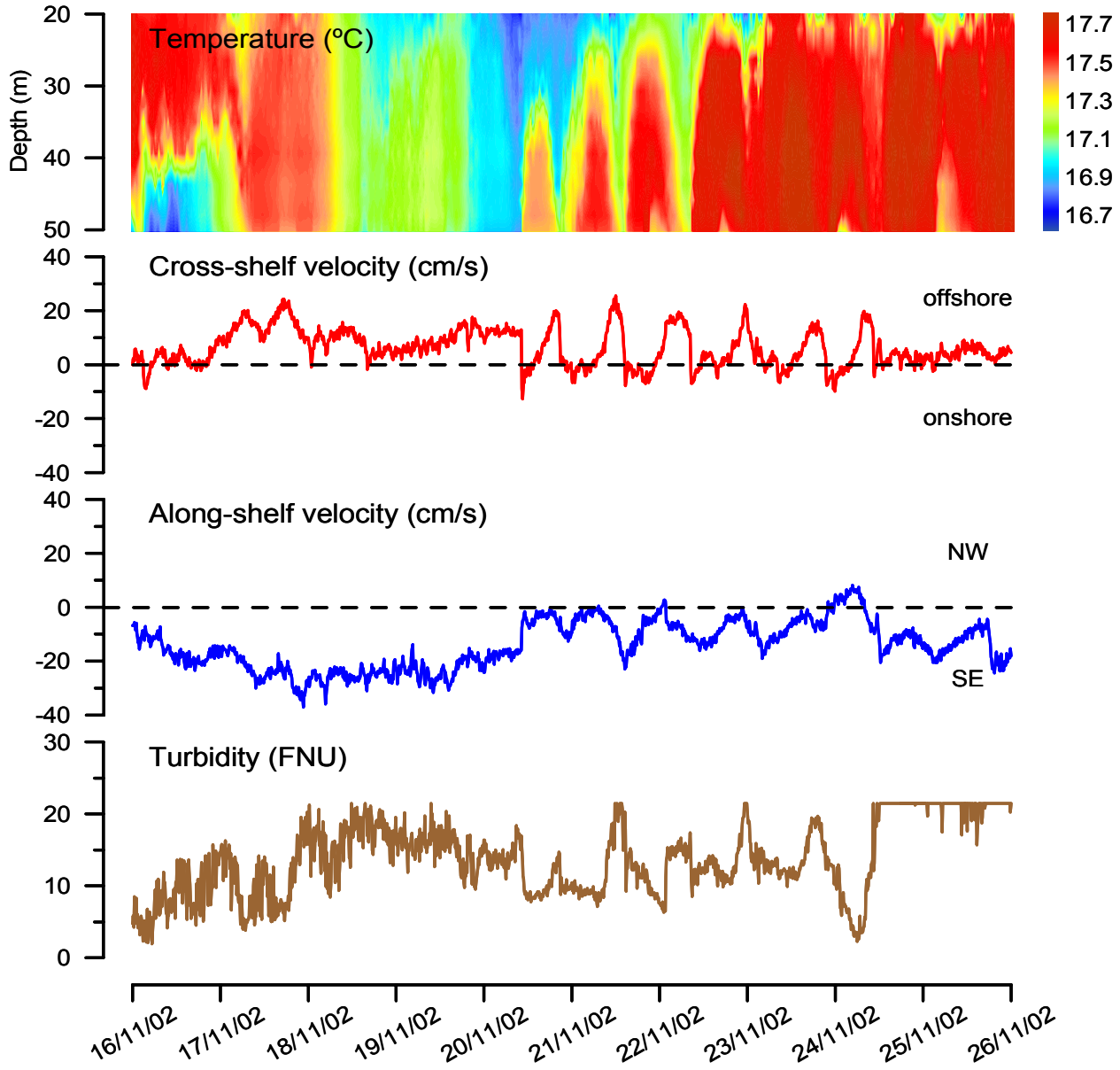

Figure 1. Detail of the measurements from the near-bottom (2 mab) current meter during periods characterized by a strong near-inertial signal. Increases of the water turbidity clearly coincide with the offshore direction of the cross-shelf velocity component and with intensifications of the along-shelf velocity component. Temperature from 20 to 50 m water depth varied with the same periodicity (17 h) as the fluctuations of the near-bottom turbidity and velocity components, suggesting a strong displacement of the thermocline and indicating presence of near-inertial internal waves. Note that velocities in the cross-shelf and along-shelf components are similar, which suggest that near-inertial internal waves greatly contribute to the offshore transport of near-bottom suspended sediment.

IMPACT/APPLICATION

Sea-floor crenulations of complex and uncertain origin characterize large portions of mud-dominated continental slopes and prograding mud wedges around the world. The observed sediment transport

processes in the Apennine shelf will provide key insight to understand the formation of crenulations in other continental margins.

TRANSITIONS

This effort will characterize the mechanisms responsible for the transport of sediment across crenulated clinoforms on the western Adriatic prograding mud wedge. Additionally, the data collected is being used for the interpretation of the sedimentary record on these crenulated fields, to characterize the Adriatic coastal current under different forcing regimes and to validate physical oceanographic and sediment transport models.

RELATED PROJECTS

EU-EuroSTRATAFORM (http://www.soc.soton.ac.uk/CHD/EUROSTRATAFORM/index.html). In addition, this observational effort will be a joint effort with other ONR funded researchers, Dr. Andrea Ogston (UW), Dr. Dave Cacchione (CME) and Dr. Charles Nittrouer (UW), as well as personnel at the Instituto di Geologia Marina (CNR) in Bologna, Italy (Dr. Fabio Trincardi and Dr. Anna Correggiari).

PUBLICATIONS

Abstracts

Puig, P., Palanques, A., Guillén, J., Cacchione, D. A., 2003. The role of near-inertial internal waves in the sediment dynamics of Mediterranean continental shelves (Poster). EAE03-A-06641, *EGS-AGU-EUG Joint Assembly,* Nice, France.

PATENTS

None